BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

System description: Continuum Surelite II-10
Location: 1008-A

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:		
Name: Craig Woody	*Signature:* ***Signature on File***	*Date:* 9/13/04

AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

C. Weilandics	***Signature on File***	
BNL LSO printed name	*Signature*	*Date*
Asher Etkin	***Signature on File***	
C-A Department ES&H Approval printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS
x Operation x Maintenance x Service Specific Operation x Fiber Optics

LASER SYSTEM HAZARD ANALYSIS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system. The analysis includes both laser (light) and non-laser hazards. A Nominal Hazard Zone (NHZ) analysis must be completed to aid in the identification of appropriate controls.

LASER SYSTEM CHARACTERISTICS					
Laser Type *(Argon*YAG:NdYAG:Nd*CO_2, etc.)*	Wavelengths	ANSI Class	Maximum Power or Energy/Pulse	Pulse Length	Repetition Rate
YAG:Nd	1064 nm 532 nm 355 nm	4 4 4	600 mJ 260 mJ 215 mJ	7 ns	10 Hz

☐ **Cryogen Use**

Describe type, quantity, and use.

_____

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

_____

☒ **Electrical Hazards**

Description *(Describe the power supply to the system).*

The factory supplied power supply operates from 220V power. No hazardous voltages are exposed during normal use. Servicing the power supply or operating the laser head with the interlocks defeated may only be carried out by qualified and authorized personnel with proper electrical safety training. Working hot rules apply whenever hazardous voltages are exposed during service operations.

☒ **Other Special Equipment**

Description *(Equipment used with the laser[s]).*

Beam splitter optics – 6 mirrors with lenses and fiber optics, 2 mirrors without lenses with fiber optics

Laser System Configuration: Describe the system controls *(keys, switch panels, computer controls),* beam path, and optics *(provide a functional/block diagram for complicated beam paths)*.

This laser is used to deliver light pulses to three of the PHENIX subsystem detectors (EMCAL, Beam-Beam and Time-of-Flight) for energy and time calibration. Light from the laser is split by a series of beam splitter optics and delivered to the three subsystems over a set of long optical fibers. The laser and its beam splitter optics are enclosed in a multiply interlocked box which serves as a controlled area. Therefore, when the interlock box is closed and operational, the laser can be operated in a Class I (fully enclosed) mode. However, the possibility for exposure to dangerous beams of both visible and invisible light exist inside the box, and only trained and authorized personnel may operate the laser with the box open and the interlocks defeated.

The laser and its beam splitter optics are shown in the diagram attached to this procedure. The laser incorporates a second and third harmonic generator to produce beams of 532 nm and 355 nm light in addition to the primary beam at 1064 nm. The beam at 532 is in the visible (green), while the 355 nm beam is in the UV and the 1064 nm beam is in the infrared and are not visible. A factory supplied beam separator package (SSP) splits the beam into these three wavelengths.

The EMCAL uses light from the third harmonic at 355 nm for energy and time calibration. The light is first reduced by a factor of 10 by a fixed mirror before reaching a second variable attenuator. This attenuator is computer controlled from outside the box and does not require access to the laser or the beam splitter optics to control the beam intensity to the detector. After the variable attenuator, the beam is split into six equal intensity secondary beams by a set of partially reflecting mirrors. Each of the secondary beams is focused with a lens onto the end of a fiber which carries the light to a series of optical connectors on the side of the laser box. The amount of energy injected into each fiber and that appears at the output connectors is < 5mJ/pulse. These connectors are used to couple to another set of long optical fibers which transport the light over a distance of approximately 50m to each of the six EMCAL sectors The light from each of these fibers is further split into multiple fibers on the detector, such that the light actually reaching each individual detector element is very low (< 0.1 microjoule/pulse).

The Beam-Beam counters use the second harmonic at 532 nm, and the Time-of-Flight system uses the third harmonic at 355 nm. For both of these systems, a low power reflection from a clear window in the beam path is used to inject a small amount of light into a fiber which again carries the light to a set of connectors on the side of the laser box. Additional neutral density filters are used to further reduce the light intensity to < 1 microjoule/pulse at the connectors. As in the case of the EMCAL, another set of long optical fibers are used to transport the light over a distance of ~ 50 m to the detector where the light is further split into multiple fibers which go to each individual detector element. In this case, the energy of the light reaching each detector element is extremely low (< 1 picojoule/pulse).

The laser box itself sits inside a separate room in the PHENIX Counting House (1008-A) which can serve as an additional controlled area when the laser is being aligned or serviced. The power supply is key locked and only operated by authorized personnel. **Only operators authorized by this procedure are allowed to operate the laser with the interlock box open for alignment or service**. However, authorized users, such as PHENIX personnel on shift, may use the laser for calibration purposes and perform simple operations using the laser as listed in the accompanying attachments.

DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

American National Standards Institute (ANSI) Standard for Safe Use of Lasers;
(ANSI Z136.1-2000)

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL

ENGINEERING CONTROLS

☒ Beam Enclosures	☒ Protective Housing Interlocks	☐ Other
☒ Beam Stop or Attenuator	☒ Key Controls	
☒ Activation Warning System	☒ Other Interlocks	
☒ Ventilation	☐ Emission Delay	

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **If any of the controls utilized in this installation requires a design review, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

See OPM 8.4~ CA-1008-1 Interlock Test Checklist

Laser was approved for operation in Building 1008 as part of the PHENIX Operational Readiness Review (ORR) on December 12, 1997. Laser operation is covered under PHENIX Operating Procedure PP-2.5.2.9-04.

Engineering Controls Description:

Beam Enclosures: Primary beam enclosures are supplied by the manufacturer for the laser and beam separator. The laser is housed inside an interlocked light tight box.
Beam Stop or Attenuator: Diffusing beam stops are installed at the end of each optical beam path. An attenuator mirror limits the intensity in the 6-fold beam splitter to 10% of the total beam intensity Attenuator mirrors and filters are used to limit the intensity of the 2-fold beam splitter to <4% of the total beam intensity
Activation Warning System: A factory supplied indicator light on the control unit shows when the laser is activated. The room where laser is located has an external lighted warning sign which is lit when the laser is operated with the box open for alignment or service.
Ventilation: The room where laser is located is adequately ventilated.
Protective Housing Interlocks: Laser housing is equipped with factory supplied interlocks.
Key Controls: Laser is equipped with factory supplied key lock for operation.
Other interlocks: The laser box is equipped with four interlocks to close the main shutter when the box is

opened. There is also an interlock override switch inside the box which activates the external warning light on the room when the laser is operated with the box open for alignment or service.

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☐ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Standard Operating Procedures (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. The BNL Laser Safety Officer must approve SOPs and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

Laser Controlled Area: The laser is normally operated fully enclosed (Class 1). If it becomes necessary to perform maintenance or service on the laser and associated optics, a temporary laser controlled area will be established within the room where the laser is situated.
Signs: Appropriate laser signs are posted at the entrance to the room where the laser is situated.
Labels: Appropriate warning labels are posted on the cover of the laser

See OPM 8.4 Att. CA-1008-1 Guidance for Normal Operations

See OPM 8.4 Att. CA-1008-1 Guidance for Alignment/Maintenance Operations

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

See OPM 8.4~ CA-1008-1 Configuration Control Checklist

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☒ Eye Wear

Skin Protection: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE) describe the nature of the hazard and the steps that will be taken to protect against the hazard.

Eye Wear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi-laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

No protective eyeware is required when using the laser in its normal operating mode (Class 1) inside its enclosed box. **Protective eyeware is required when operating or adjusting the laser when the box is open.**

Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
Nd:YAG	1064 nm 532 nm 355 nm	7(10 sec.) 6.2(0.25 sec.) 4(10 sec.)	4(600 sec) 3.6(600 sec.) 2.3(600 sec.)	18.3 m 10.8 m 2.8 m	

* Diffuse ODs are calculated assuming a 600 second exposure, a viewing distance of 20 cm, perfect reflectivity, and viewing normal to the surface. The ODs required can decrease for more typical conditions in the laboratory.

**The Nominal Hazard Zone is that zone or distance inside which exists a hazard to the eye from a diffuse reflection (as well as direct or specularly reflected light) for the time specified, in this case, 600 seconds (10 minutes).

***Specified eyewear may not be the only possible option, but represents an approved choice; depending on other laser hazards present in the lab, other eyewear may be acceptable provided the optical densities are equivalent or greater than those required.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density
YAG laser goggles (Glendale LSR-Gard B Series LGS LQO29)	1064 nm 532 nm 355 nm	>7 >7 >9

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

See OPM 8.4~ CA-1008-1Training Checklist

All laser safety training must be repeated every two years.

See BTMS

TO BE REPLACED BY Laser Specific JTA in BTMS
ATTACHMENT 1- QUALIFIED LASER OPERATORS

The Qualified Laser Operators for this laser system are listed below.

Qualified Laser Operators:

Basic Laser Training	Job-Specific Training	Medical Surveillance	Printed Name	Signature	Owner/Oper. Initial/date
6/27/03	yes	2/11/92	Craig Woody		
6/17/03	yes	4/22/92	Sean Stoll		

Signature above indicates that the qualified laser operator has read and understood this procedure and has been trained in the system specific operation of this laser.

TRAINING CHECKLIST

All qualified laser operators must read and understand the following system specific checklist.

- For normal Class I mode of operation, both lids of the interlocked box must be closed and all fiber optics outputs must be terminated.
- Check that interlock certification is current as per interlock test procedure.
- To operate the laser with the interlocked box open, a temporary controlled area must be established in the room where the laser located as specified by this procedure.
- Protective eyeware must be worn at all times when the laser is operated with the box open and the interlocks defeated.
- All qualified laser operators must read and understand the procedure listed below.

IDENTIFIED HAZARDS

The following list identifies the hazards specifically associated with the laser described in this procedure.

Operation:

- All beams from the laser are normally totally contained during normal routine Class I operation and no specific eye protection is required. Light from the output fibers to the EMCAL, Beam-Beam and Time-of-Flight detectors are low power, **but one should never look directly into the fibers or into the exit ports.** The light delivered to the EMCAL and TOF fibers is at 355 nm, which is in the UV and not visible. The light delivered to the Beam-Beam counters is at 532 nm and in the visible green part of the spectrum. However, the Surelite laser is also capable of producing light at 1064 nm, which is in the infrared and is not visible. All beams are dangerous and require eye protection when the laser is operated without total beam containment.
- In normal Class I operation, authorized users, such as the PHENIX Shift Crew, may perform simple operations using the laser. These operations are limited to the following:
    - Turning the laser on and off with the key switch
    - Pushing the shutter open and close button on the front panel of the power supply
    - Resetting an error condition as indicated on the front panel by cycling the power on and off (and noting the error code in the Error log sheet)

- Adjusting the light intensity to the EMCAL sectors by controlling the variable attenuator with the computer

All PHENIX personnel are required to take PHENIX Awareness Training which indicates the hazards of the laser in the PHENIX Counting House, and the shift crew is required to take PHENIX shift training which specifies what they are allowed to do with the laser while on shift. All other personnel authorized to perform the above Class I operations shall have task specific training and be listed outside the laser room.

In addition to these routine operations, authorized members of the Beam-Beam and Time-of-Flight subsystems may change the fixed neutral density filters in the Beam-Beam or Time-of-Flight fiber outputs inside the laser box. To do so, the box must be in its normal interlocked mode, and the user must push the shutter close button and check that the indicator light shows that the internal shutter has been closed before opening the box. Members of the Beam-Beam and Time-of-Flight subsystems must read and acknowledge that they have understood this procedure to become authorized to perform this operation, and a list of these authorized users will be posted outside the laser room.

Any other operations or adjustments inside the box can only be performed by the authorized operators listed in this procedure.

OPM 8.4 Att. CA-1008-1 Guidance for Alignment/Maintenance Operations

Alignment:

- Alignment of the laser beam or any of the internal beam optics must be done with the interlocked box open.
- This requires establishing a temporary controlled area in the room where the laser is located.
- All unauthorized personal must leave the room and any personnel working in the immediate area of the laser room must be notified that the laser is being operated in an open mode inside the room.
- The operator must insure that no one is working overhead that could inadvertently look into the laser room from above, and a watch person must be stationed outside the room to insure that no unauthorized personnel enter the room while the box is open and the laser is on.
- The operator must also check that the “LASER ON” warning light comes on outside the room when the laser is operated with the interlocks defeated.
- All operators in the room must wear appropriate safety goggles as indicated above during the alignment procedure.
- **However, never view the beam directly even with safety goggles.**
- **The alignment can be checked by inserting a small white card into the beam path and viewing the fluorescence from the card from the side while wearing safety goggles**.
- Whenever possible, the alignment should be done with the laser power as low as possible.

- Alignment of the internal optics of the laser requires removing the main cover from the laser and defeating the factory supplied interlocks.

- These interlocks are in addition to those on the interlocked box.
- Safety goggles must always be worn whenever working with the laser with the cover removed and the laser energized. In addition to potential exposure to the primary beam,hazardous voltages may also be present on certain internal components of the laser.
- Any work with the main cover off and the power on requires an evaluation by a Work Control Coordinator to determine whether the task requires Enhanced Work Planning.

Maintenance:

Routine maintenance for the Surelite involves periodically changing the flash lamp and cooling water filter, and cleaning the beam optics. Depending on usage, this maintenance may be performed on the order of every few months. Since these operations are done with the laser off, there are no hazards associated with these procedures. However, care should be taken when changing the flash lamp, which is delicate and can be easily broken

Service:

- Any service beyond routine maintenance would be performed by a factory-trained technician or the laser would be sent back to the factory for service.

OPM 8.4~ CA-1008-1 Interlock Testing Checklist

Interlock Testing Checklist:

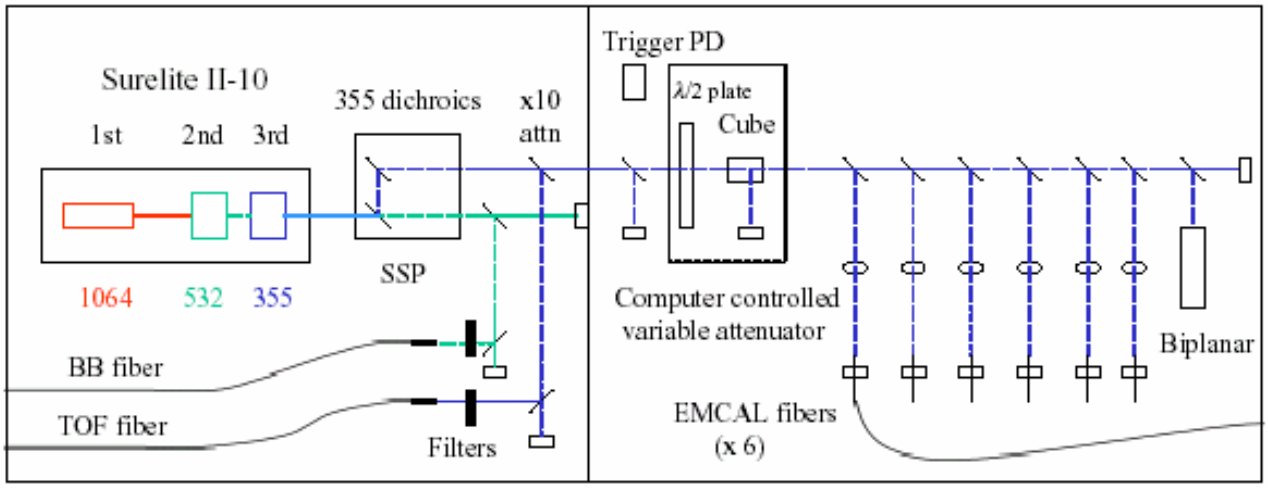
The interlocks on the laser box must be tested every six months and documented by this checklist that is retained at the laser.

1._____ Put on laser safety goggles.
2._____ Start the laser and bring it into its normal operating conditions according to the procedure described in the manufacturers operating manual.
3._____ Turn on the bias voltage to the trigger photodiode inside the laser box and verify that it is set to +25V.
4._____ Connect a fast oscilloscope to the output connector on the laser box labeled “Trigger Output”
5._____ Verify that the photodiode is detecting light from the laser pulse/
6._____ Open the lid of the right side of the laser box slightly until the shutter is heard to drop into place and verify that the signal from the photodiode disappears.
7._____ Close the lid and verify that the signal reappears.
8._____ Repeat step 6 for the left side of the box.

OPM 8.4~ CA-1008-1 Configuration Control Checklist

Prior to operation after a sustained shutdown the laser area is to be inspected to insure it conforms to this SOP and the following check list completed:
1 All sign and labels intact and in place.
2 All Fiber Optic outputs terminated.
3 Interlock certification current as per test procedure.

ATTACHMENT 1 - PHENIX YAG laser and Beam Splitter Optics



< 1 microjoule/pulse

< 5mJ/pulse